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Field study on the president costa e silva bridge (steel structure),Progress Report No. 3, May 1975

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PROGRESS REPORT No. 3

(Period from 1 October 1974 to 31 March 1975)

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(STEEL STRUCTURE)

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This report summarizes the activity on the project from 1 October 1974 to 31 March 1975 and presents some sample results to illustrate the level of progress.

1. GENERAL SUMMARY

This progress report (No. 3) covers the time from 1 October 1974 to 31 March 1975 during which an additional trip to Rio de Janeiro was carried out by the Lehigh University team in order to conduct the final temperature readings on the bridge. Three particular periods can be distinguished: 1 - prior to the trip to Rio, 2 - the trip itself, and 3 - the period after the trip. The estimated degree of completion of the project is 85% and the principal task remaining is the preparation of the final report.

Period 1: 1 October 1974 to 4 January 1975 - Analysis of the Field Data Obtained Previously and Writing of the Report

Most of this period was spent on the continuation of the analysis of the cross frame bending stresses and of the force history of the bridge (scratch and mechanical gages). The computer program for the analysis of the cross bending stresses was amplified to handle the full double box cross section of the bridge. Bridge traffic data has been received from ECEX and classified for analysis, but the data reduction has been postponed since further work requires the accumulation of traffic data for at least one year. Some parts of the final report were drafted during this period. Preparations for the additional trip to Rio de Janeior authorized by ECEX to conduct additional temperature measurements consisted primarily of making extensions for the scratch gages in order to make them more sensitive.

The Project Progress Schedule of Fig. 1 indicates continuation of work on Phases IIIA (Data Reduction), IIIB (Analysis) and IIIC (Report Preparation).

Period 2: 5 January to 19 January 1975 - Trip to Rio de Janeiro for Additional Temperature Studies

On 5 January 1975 Professor A. Ostapenko and Messrs, H. T. Sutherland, J. E. O'Brien and D. H. DePaoli went to Rio for conducting additional studies on the temperature distribution in the completed bridge structure under the extreme summer temperatures. It was necessary to completely check out the whole instrumentation system of strain and temperature gages and repair and modify it for the tests. Fortunately, the final clean-up and painting of the bridge since June 1974 caused only relatively minor damage to the gages. All scratch gages were modified by installing extensions to increase the gage length from 30cm to 100cm so that the traffic and thermal stresses in the completed bridge could be more accurately recorded. (The smaller, 30cm-gage length was more appropriate for the high construction stresses.) The scratch gage which had been previously damaged, was brought back from the U.S. after repairs and reinstalled in the bridge. A complete set of mechanical gage readings was also taken.

An unforeseen difficulty was encountered with the B&F data acquisition unit when it was discovered that may switching relays in it were malfunctioning due to corrosion on the contact surfaces which developed since June 1974 (then the unit was in perfect order). No explanation could be found for the corrosion except for a possibility that the sulphuric air impurities may have substantially increased during this period compared to the previous levels. Only after replacing a number of relays was it possible to take reliable readings.

The success of this field reading period should be in no small measure credited to the ready assistance and competence of the SEOBES staff (Secao de Observacao de Estruturas) under Dr. Paulo Soares da Costa. Particularly gratifying was their willingness and ability to learn about the instrumentation and operation of the equipment.

Upon completion of all planned studies, the Lehigh University team left for home with confidence that the SEOBES team would be able to continue any additional operations on the bridge instrumentation and extend the use of the equipment to other projects if necessary.

Work of this two-week period is marked in the Project Progress Schedule of Fig. 1 by the completion of Phases IIB and IIC.2.

Period 3: 20 January to 31 March 1975 - Reduction of Readings made in Period 2 and Work on Final Report

The strain and temperature readings taken in January 1975 were promptly reduced using the computer programs developed previously. Only minor modifications were needed to accommodate the new gage groupings. The resultant patterns of the maximum temperature and strain changes were then used in the thermal analysis program.

The newly collected scratch gage targets and the mechanical gage readings were analyzed in the course of the force history study.

The major activity for the last month has been in drafting some chapters of the final report.

Summary

The reserach progress for this report period (1 October 1974 to 31 March 1975) is entered for each Phase in the Project Progress Schedule of Fig. 1. It shows a good agreement of the overall estimated degree of completion of 85% versus the projection of 88%. The principal remaining activity is the preparation and production of the final report.

2. RESEARCH PROGRESS

In the following some representative items of the contract research are presented to illustrate the level of progress.

(1) Cross Bending due to Poisson's Ratio Effect

Strain readings from the transverse gages installed on the floor beam and transverse vertical and bottom stiffeners at FB27 and 42 indicated considerable stress changes, especially during construction. Figure 2 shows the transverse strain distribution measured at FB42 during the transfer of the side span from the jetties to the pontoon. The non-uniform distribution across the depth of individual members indicates the curvatures developing in them. A computer program was completed previously for the analysis of these stresses and for the determination of the effective width of the plate participating in the deformations of the transverse frame formed by the floor beam and the stiffeners. Results of the analysis have shown stress changes (up to 600 kg/cm^2) which, although not critical for the Rio-Niteroi bridge, may be important for other structures and thus should be considered in design. The effective plate width was found to be 30% of the member length for the floor beams and 19% for the transverse vertical and bottom stiffeners. This study has been finished and the chapter describing it for the final report drafted.

(2) Temperature Studies

Although the temperature readings during the June 1974 trip to Rio were of limited nature and could not be used for a complete bridge analysis, they indicate a consistent and continuous relationship between the temperature and strain changes in the bridge with respect to time. The additional field trip authorized by ECEX for January 1975 provided full temperature data and Figure 3 gives an example of the distribution of a diurnal temperature change measured at FB57. Analysis of this data by means of a previously developed computer program gave stresses which are in good agreement with the stresses measured by scratch gages.

(3) Mechanical and Scratch Gages (Force History)

Mechanical gage readings have been analyzed and they indicate no noticeable change in the bridge forces after construction of the bridge. The observable deviations can be readily ascribed to the time of day as affecting the temperature distribution in the bridge since, as was expected, stresses due to live load are very small in this large structure and the principal contribution to stress fluctuations is due to temperature changes.

Scratch gages have recorded the stress changes quite faithfully but not very accurately. Increase of the gage length in January 1975 noticeably improved the accuracy. Figure 4 shows a scratch gage trace obtianed with a 30cm gage length and a comparable trace obtained with a 100cm gage length. The zigzags of the new trace are seen to be much more pronounced and the threshold of target advancement has been substantially reduced. In this manner it is hoped that the formation of repetitious zigzags in the same area (blobs) will be avoided and a more detailed thermal stress history can be recorded.

(4) Stress History

All data reduction associated with the bridge traffic data which has been accumulating since March 1974 was postponed until approximately one year of traffic data has been received. Up to the end of March traffic data was complete from 4 March 1974 until 9 December 1974. Consequently no work except for classification of the received data was performed during the interval covered by Progress Report No. 3.

3. FUTURE WORK

As the Project Progress Schedule of Fig. 1 shows, Phases I and II have been completed. Only relatively minor effort is needed on the analysis of the strain, temperature and scratch gage data, and most of the impact for the remainder of the project will be on the preparation and production of the Final Report. New field data is expected only in the form of the scratch gage targets for the period since January 1975 when they were installed in the bridge. It would be helpful if the daily temperature records for this period and if possible for the time since June 1974 were available.

Work on the stress history studies will be resumed upon receipt of the traffic data for the period till 4 March 1975.* The general steps involved are as follows:

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*The last batch of traffic data up to 9 March 1975 was received on 14 April 1975.

(a) Record the total volume of vehicles crossing the bridge both ways by class during the period March 4, 1974 to March 4, 1975. Classes 4 to 8 as recorded by DNER are of first interest in the stress history studies.

(b) Determine the total number of axles within classes 4 to 8 which crossed the bridge from Niteroi to Rio de Janeiro during the period March 4, 1974 to March 4, 1975 (the same number of axles crossed the deck test section near FB17 near Pier 99 which was monitored in June, 1974).

(c) For the number of axles which crossed the deck test section during the field study period May 30 to June 6, 1974, construct frequency histograms of stress range occurrences for each gaged location on the deck.

(d) Extend the analysis to predict deck life based on projected traffic volumes.

Accuracy and reliability of this analysis would be significantly increased if DNER could supply the researchers with the gross vehicle weight distribution of trucks for typical main arteries similar to the Rio-Niteroi bridge. This may be available from a loadometer survey conducted since 1970.

Fig. 1 PROJECT PROGRESS SCHEDULE

Progress to March 31, 1975

RESEARCH PHASE	ITEM *	1973 A	S	O	N	D	1974 J	F	M	A	M	J	J	A	S	O	N	D	1975 J	F	M	A	M	J	J	A	Est. % Compl.
I ERECTION STRESSES																											
A. PLANNING & PREP.	1	100																									100
B. INSTRUMENTATION & MEASUREMENTS	2, 3 & 4				100																						100
II COMPLETED BRIDGE																											
A. PLANNING & PREP.	1				80				90		100																100
B. INSTRUMENTATION	2, 3 4, 5				80								(100)						100								100
C. STRESS MEAS.																											
1. Controlled Load, Temp.	5						100																				100
2. Normal Traffic & Temp.	6												(100)						100								100
III A. DATA REDUCTION	7					4			10		20		35		55		80	90	100								95
B. ANALYSIS	7, 8								5		10		25		40		60		80		90		100				90
C. REPORT PREPARATION	8								5	P		10			20	P	35		50		65	P	80			F 100	50
OVERALL COMPLETION		3	8	11	16	19	22	28	32	36	40	45	50	55	60	65	70	75	80	84	88	92	94	96	98	100	85

* Items in Exhibit A of Proposal

Actual Effort

Planned

(100) Planned Initially, but Revised

P = Progress Report

F = Final Report

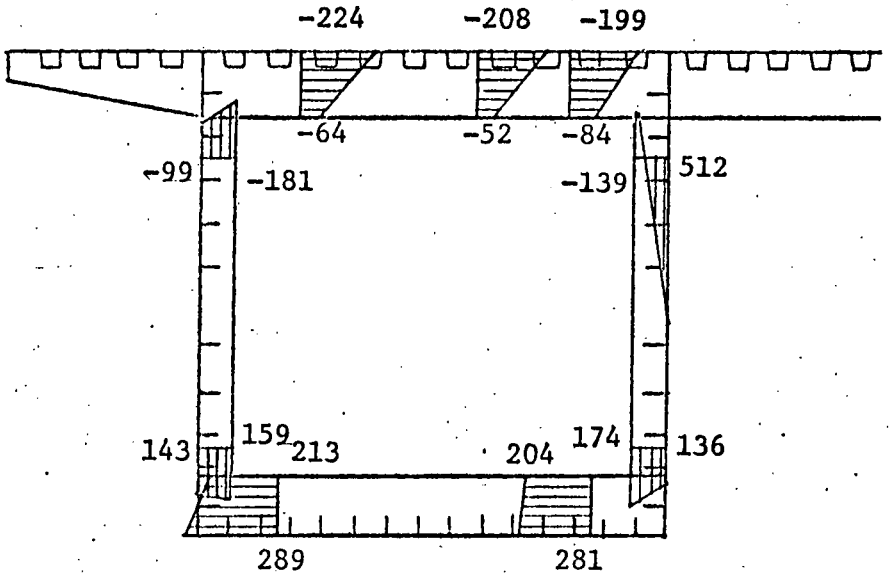
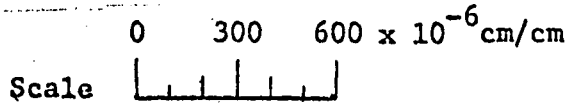


Figure 2 : Transverse Strains at FB42 (Jetties to Pontoon)

North Box



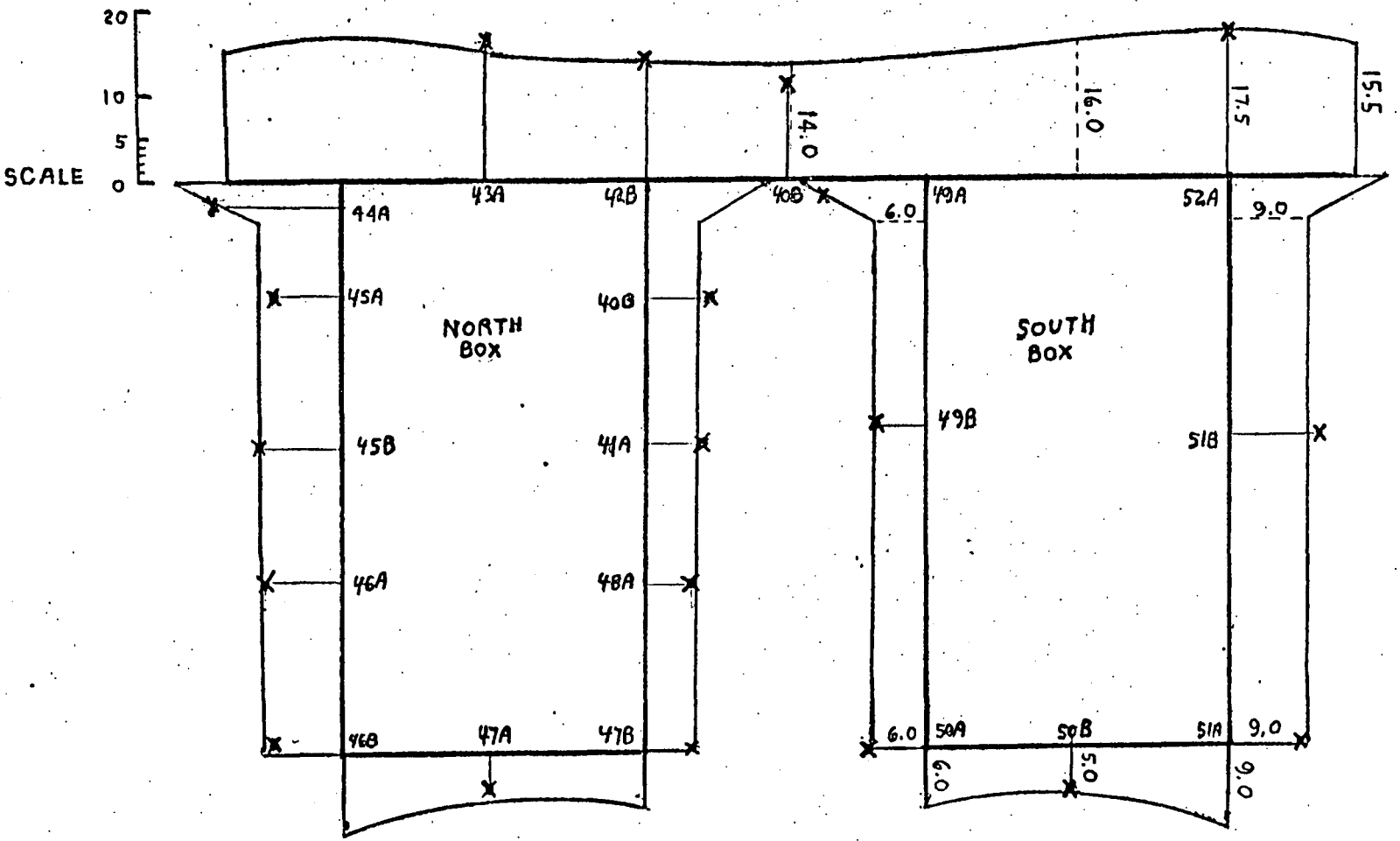


Fig. 3 Typical Temperature Change Distribution
FB57 (Center Pier No. 100)

FB57- TEMP CHANGE (°C)
6:30-15:00 HRS.
17JAN75
43A, etc. ARE TEMP.
GAGE NOS.

6 JUNE 1974 - 10 JAN 1975
(PORTION)

GAGE LENGTH = 30.5 cm

STRESS CHANGE
4.0 KSI (AT ARROW)

11 JAN 1975 - 15 JAN. 1975

GAGE LENGTH = 100 cm

STRESS CHANGE
3.6 KSI (AT ARROW)

Fig. 4: Comparison of Scratch Gage Traces for Different Gage Lengths

(FB42-Bott.; Magnification = 210X)